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(54) Title: IMPROVED DELIVERY SYSTEM AND METHOD FOR REDUCING OXIDATION AND RANCIDITY OF EDIBLE COOKING OILS AND/OR FATS

(57) Abstract

An improved method and capsule for the controlled addition of antioxidant to an edible cooking oil composition includes an edible capsule shell containing a predetermined amount of an approved antioxidant such as BHA, BHT or TBHQ or any of the other known antioxidants. The capsule assures that a known amount of antioxidant is added, and the capsule is of a density such that it sinks to the bottom of the heated oil. The heat softens the capsule wall, which is preferably gelatin, and causes a pressure increase within the capsule to rupture the same and release the antioxidant. Various materials and suggested amounts are disclosed with reference to the size of the fryer to which the antioxidant is added.

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IMPROVED DELIVERY SYSTEM AND METHOD FOR REDUCING OXIDATION AND RANCIDITY OF EDIBLE COOKING OILS AND/OR FATS

Field Of Invention

This invention relates to the reduction of oxidation and thus the rancidity of edible cooking oils and/or fats, and of the products cooked with such oils or fats, and more particularly to an improved delivery system and method for effectively and simply delivering an effective amount of an antioxidant to an edible oil and/or fat material such as may be used in deep fat frying of various foods under conditions of substantially continued or short time intensive use during the normal day.

Background Of The Invention

With the advent of fast food chains and the popularity of the various products prepared by deep frying, attention has been focussed on the well recognized problem of inhibiting the oxidation and rancidity of the cooking medium used in deep fat frying and of the products cooked thereby. Typically, these operations involve the use of commercial sized deep fat frying systems which may vary in size from thirty five to one hundred pounds of cooking medium, e.g., between about 16 kg. to about 45 kg., for example. Usually, the cooking systems include circulation and clean-up systems which operate to recirculate the hot cooking fluid during use. Typical such operations are the so-called fast food operations in which potato or onion products are deep fried, or in which fish or poultry products are deep fat fried. Other commercial operations include potato chip or other chip type manufacturing in which potato or corn type products are deep fried.

In addition to the problem of oxidation of the cooking medium, there is also the related problem of the rancidity of the cooked product since a portion of the cooking medium is carried out with and remains with the cooked product. Typical such products are potato chips and corn chip type products and the like. In such products, the focus is on

preventing oxidation and rancidity of the cooked product, thus extending the shelf life and the quality of the product, in which case the stability of the cooking medium is a lesser, though important consideration.

Other operations in which deep fat frying is carried out is in schools, but there the cooking period is relatively short as compared to commercial operations. Nonetheless, in each type of cooking operation the problems related to oxidation and rancidity are essentially the same, albeit perhaps more acute in the commercial operations.

In deep fat frying, be it on a commercial long continuous period basis or for a relatively short period basis, as for example in a school lunch program, the cooking oil is subjected to high temperatures, and is exposed to atmospheric oxygen and water, the latter usually carried into the cooking medium with the product being cooked. Depending upon the type of cooking oil or combination of oils and/or fats used, these conditions may result in oxidation, hydrolysis and polymerization of the cooking medium, the visible signs of which are darkening of the oil, increase in viscosity, lowered smoke point, and rancidity.

Usually the cooking medium is an oil or fat or mixture of oils and fats, of an edible variety and of a vegetable or animal origin, and may exhibit a tendency to become rancid due to oxidation thereof, a process that is accelerated due to the relatively high heats used during cooking, especially on a commercial scale. Typical cooking temperatures for such cooking oils and/or fats, referred to herein as the cooking medium for convenience, may be in the range of from about 350 degrees F. to about 400 degrees F., e.g. in the range of about 175 degrees C. to 200 degrees C.

This thermal and/or oxidative deterioration of the cooking medium has been dealt with in several different ways. Some cooking oils or fats have natural antioxidants present, for example, citrus oils contain Vitamin A. Once the Vitamin A loses its potency, the oil becomes bitter. In

the case of lard or tallow, for example, wheat germ has been used to prevent oxidation due to the presence of natural antioxidants in the wheat germ, typically tocopherol type compounds. In other instances, the oil and/or fat, particularly refined vegetable oils have been hydrogenated to reduce oxidation. Hydrogenation, however, is a comparatively expensive process resulting in higher prices for hydrogenated refined vegetable oils.

One simple but comparatively expensive solution to the problem of controlling oxidation has been to replace the cooking medium at the appropriate time when it was determined that the cooking medium was no longer usable. Unfortunately, due to the expense of replacement, there was a tendency of the users to continue the use of the deteriorated cooking medium beyond its useful life, with the result that the quality of the cooked products varied in relation to the age of the cooking medium. In those instances where it is desired to maintain the quality of the cooked product from day to day and from one location to the next, as for example in fast food or convenience food outlets, this approach was not entirely satisfactory.

In about the mid 1970's, it was discovered that thermal and oxidative decay of the cooking medium could be retarded by the use of antioxidants. Various such materials are known in the art and described in any number of prior patents, see for example, United States Patents 3,883,673; 3,852,502; 3,867,445; 3,873,466; 3,969,383; 3,955,005; 4,022,822; 4,038,434; 4,044,160; 4,055,617; and 4,115,597 to mention only a few.

United States Patent 4,115,597 describes a system which includes a pump and filter system for recirculating the oil, a makeup oil reservoir and an antioxidant addition system in which the antioxidant is an aqueous emulsion. The continuous addition of the antioxidant is said to increase the life of the oil up to 500%.

Historically, propyl gallate (the n-propyl ester of

3,4,5-tri-hydroxybenzoic acid) was used as an antioxidant, but it suffered the disadvantage of being rapidly depleted. More recently, materials such as tertiary butylhydroxyquinone (TBHQ), butylated hydroxyanisole, which is a mixture of the 2 and 3 isomers of tert-butyl-4-hydroxyanisole (BHA), and butylated hydroxytoluene (BHT) have been used as antioxidants. These materials are available in food-grade quality from Eastman Chemical Products, Inc. under the trademark "TENOX", and are supplied in a variety of forms and formulations. The FDA permits the use of BHA, BHT propyl gallate, and TBHQ, singly or (with one exception) in combination of two or more in a maximum concentration of 0.02% of the weight of oil or fat, see 21 CFR 182.3169, 182.3173 184.1660, and 172.185. The one exception is that TBHQ is permitted for use only with BHA and BHT, and may not be used with propyl gallate. In some of these formulations, other materials are present, for example, citric acid used as a chelating agent or synergist, and solvents or carriers such as vegetable oil, propylene glycol or glyceryl mono-oleate, for example.

It is well recognized that antioxidants of the type described are not preservatives and do not function as such. Preservatives are generally materials which inhibit bacterial activity such as mold growth. Typical preservative materials are calcium proprionate, sorbic acid, potassium sorbate, parabens, acetic acid and proprionic acid, to mention a few. Antioxidants do not function as preservatives and the latter do not function as antioxidants.

To date the practice has been to add the antioxidant to the cooking medium through the addition of makeup oil containing an approved amount of an approved antioxidant. Normally, the oil contains antioxidant to inhibit oxidation prior to use and during use, and the the addition of new oil to make up for that lost in the cooking medium introduces antioxidant into the cooking medium. The difficulty,

however, is that the antioxidant is rapidly depleted in the first eight to nine hours of continuous frying and the addition of makeup oil never provides sufficient antioxidant, within the range permitted, for effective inhibition of oxidation.

Another method is the direct addition of the antioxidant to the cooking oil which has been heated to between 145 and 175 degrees F. (63 to 80 degrees C.), while the cooking oil is agitated to cause motion in the oil. After addition, agitation is continued for about 20 minutes. In another method, the antioxidant or a concentrate of the antioxidant is proportioned into the cooking medium through a pipeline, using a stainless steel proportioning pump. In this procedure all of the piping through which the antioxidant flows should be of stainless steel or glass. It is also known that it is difficult to pelletize antioxidant materials, especially TBHQ, due to the need of excipients which do not have good oil solubility. Thus, the components needed to pelletize the antioxidant materials tend to have qualities adverse to the qualities needed in the cooking medium.

U.S. Patent 4,473,620, however, discloses a free flowing BHA material in which an edible polymer is used to form a film around melted BHA in droplet form thus forming a particulate BHA product in which the particles are polymer coated to provide a free flowing quality to the BHA.

From the above it becomes apparent that a more efficient and comparatively simple method for introducing a know and effective amount of a permitted antioxidant into a cooking medium is desired, especially one which will not adversely affect the cooking oil. The use of materials which are incompatible with the oil or insoluble in the oil generally should not be used since there is a danger that significant amounts of such materials will be carried out with the product being cooked.

Thus, one of the principal objectives of this invention

is to provide a relatively simple but effective system to provide a controlled and known amount of an antioxidant which is in a form which does not adversely affect the cooking medium to which it is added.

Another object of this invention is to provide a known and effective amount of an approved food-grade antioxidant material having an effective active amount of antioxidant qualities for use as a single dose component for addition to a cooking medium of a specified amount for the inhibition of oxidation.

Still a further object of this invention is the provision of a relatively simple, but effective method of delivering an effective and controlled amount of an antioxidant as an additive, in a capsule form, to a cooking medium.

Brief Description Of The Invention

In accordance with this invention a capsule is provided which contains an effective and permissible amount of an antioxidant or combination of antioxidants, the antioxidant materials being those recognized as useful for the purpose of inhibiting oxidation of a cooking medium and being operative to extend the useful life of the cooking medium far beyond what it would be if the capsule were not added.

In a preferred form of the invention, the antioxidant material, and preferably one or more compositions approved for use as an antioxidant, is packaged in an oil suspension medium and packaged in an oil compatible capsule which, in accordance with this invention, is preferably a soft elastic gelatin capsule. The described gelatin capsule is oleophobic (hydrophilic) and thus compatible with the material contained within the capsule and the oil-like material into which it is placed. The capsule wall material tends to soften at the elevated temperature of the cooking medium and the heat of the cooking medium is transferred into the interior of the capsule generating a pressure internally thereof, resulting is rupture of the heat

softened capsule from inside out. Upon rupture, the interior contents of the capsule are released, and dispersed throughout the cooking medium as a result of the natural movement of the oil-like material which is preferably at its normal temperature of use. Since the capsule is of gelatin, a food grade product, it does not adversely affect the cooking medium. Further, the capsule density is greater than that of the heated cooking medium such that the capsule sinks to the bottom of the oil bath where it is heated to the softening point and ruptures with the resultant release of the contents, all of which are soluble in the cooking medium. Since the antioxidant is preferably dispersed in and oil and somewhat wet by the oil, it is easier to disperse and to dissolve that the same material added dry to the cooking oil.

The remaining solid components of the capsule remain at the bottom of the oil bath, since the density thereof is grater than the density of the cooking medium, with the result that the solid capsule residue, food grade gelatin, is cooked by the cooking medium, but remains at the bottom of the bath. If not removed by the filter system usually present in commercial deep-fat fryers, it is fully cooked, appearing somewhat similar to the appearance to a small portion of an overcooked piece of potato, i.e. a small almost black char. Even if that part should end up in the product in the hands of the consumer, as occasionally happens with the product being cooked, it is either discarded by the consumer and not eaten or, if eaten, it is as consumable as any other char product of the food being cooked.

The singular advantage of the capsule product of this invention is that it provides a simple, but effective, delivery system for introducing into a cooking medium an effective and controlled amount of an antioxidant composition which is premeasured to assure that the permissible limits of the antioxidants are not exceeded.

Thus, for example, the capsules may be formulated to accommodate deep fat fryer systems of different capacities, e.g. 35 pounds, 50 pounds, 75, pounds or 100 pounds, or more. It is relatively simple to provide simple instructions and controls to assure that the maximum permissible limits of permissible antioxidants, in excess of 0.02% by weight of the oil, are not exceeded in any particular system. Since the antioxidant is packaged in single dose compatible capsules, it is relatively simple it assure that the packaging is such, and the controls are such that each capsule is accounted for in the routine operations involving unskilled workers.

DETAILED DESCRIPTION OF THE INVENTION

In a preferred form of this invention the cooking medium is an edible oil or fat or a combination of edible oils and fats typically used in deep fat frying. As will be understood, there are numerous oils and fats used in such operations, and the compositions thereof vary considerably. Some exhibit far more stability to oxidation than others, and some are prone to what is called "flavor reversion", as will be described in the following discussion. The various oils and fats, all edible, have different and unique qualities, in terms of their susceptibility to oxidation or the formation of rancid products, over an extended period of time. This invention does not claim to be the broad solution to the general problem of rancidity due to oxidation, but rather to an improved and relatively simple solution to that problem. Some of the products used in deep fat frying are recognized as being inherently resistant to oxidation due to the chemical nature of the oil or fat or combination thereof, and those qualities of the components of the cooking medium are known. Nonetheless, the literature and the published data recognize that the use of the permissible antioxidants, in the amounts approved, are effective to increase the useful life of the cooking medium for a significant period of time, as compared to the same

material without the use of antioxidants.

For example, soybean oil is used in shortening, margarine and cooking oil and is highly unsaturated, containing a high amount of linoleic acid, leading to what is called "flavor reversion". This attribute of the product may be countered by partial hydrogenation or the addition of a chelating agent such as citric acid. Nonetheless, antioxidants do operate to stabilize the oil against oxidation.

Palm oil is really a fat in that it is a semi-solid at room temperature. The enzymes in the pulp of the source fruit lead to hydrolytic rancidity which is not responsive to antioxidants. Heat treating of the pulp tends to inactivate the problem enzymes. This particular product is a highly saturated material. Stability of this oil may be improved by the sue of THBQ. This oil is used in margarine, shortening and frying oil.

Sunflower seed oil is used as a cooking oil. It is composed of generally 85% or more of unsaturated fatty acids and responds well to antioxidants.

In contrast, cottonseed oil, also used as a cooking oil, has a relatively high oxidative stability, but exhibits enhanced oxidative stability when antioxidants are added.

Cottonseed oil is principally a lauric acid fat with a sharp melting point and a somewhat bland flavor. It is highly resistant to oxidation and is normally not used as a cooking oil. It is susceptible to hydrolytic rancidity which gives a soapy flavor to the oil or to the food cooked in rancid cottonseed oil. While antioxidants will not inhibit hydrolytic rancidity, they do increase inhibition of oxidative rancidity.

Peanut oil is used as a cooking oil and has a high degree of unsaturation in comparison to other vegetable oils. Stability against oxidation is enhanced by the use of antioxidants.

Rapeseed oil has a high content of long chain fatty

acids and has a high viscosity compared to other vegetable oils. It is usually used in shortening and cooking oils. Like soybean oil, it has a comparatively high content of linoleic acid and is susceptible to flavor reversion. Nonetheless, antioxidants are effective in inhibiting oxidation and rancidity due to oxidation.

Olive oil is used principally for cooking and as a salad oil. It has a low fatty acid content and somewhat greater oxidative stability than other vegetable oils. It is high in flavor and odor and these qualities of this oil tend to mask rancidity. This oil responds well to antioxidants and chelating agents.

Palm kernel oil in large measure resemble coconut oil in that it is highly resistant to oxidation since it is composed largely of saturated fatty acids. This oil responds well, as does coconut oil, to antioxidants.

Sesame seed oil is used as a cooking oil and is rather unusual from a oxidation point of view. This oil contains a number of phenolic compounds, typical of the antioxidants thus far discussed, such as sasamine and sesmoline, which operate as antioxidants. This particular oil has high resistance to oxidation but is generally not used in large commercial operations. It is sometimes used in the preparation of oriental foods prepared by deep fat frying in which the flavor of the food is consistent with the oil used. Antioxidants may not be needed with this particular oil.

Corn oil is used principally as a cooking oil. It is usually partially hydrogenated, but nonetheless is prone to oxidation and responds well to antioxidants.

Safflower seed oil is the most highly unsaturated edible oil known. It responds well to the use of antioxidants.

In addition to the above, there are a number of edible animal fats, such as lard and poultry fats which may be used as cooking oil or as a component of cooking oil. It is

recognized, however, that the bulk of the oils used for deep fat frying are vegetable oils such as soybean oil, sunflower oil and palm oil, all of which may have their useful life extended through the use of antioxidants.

As will be understood, in commercial operations, or in operations involving the preparation of deep fat fried products on a scale grater than home operations, the problem of oxidation of the cooking medium is of concern since the cost of the cooking medium and the expense of replacement may be a significant factor. Thus, the rarer oils may be too expensive for commercial or school operations. The more common oils may not be acceptable where a particular flavor is desired, as may be the case for foods prepared in accordance with the oriental requirements. The use of partially of fully hydrogenated oils or fats may not be economically advantageous for large commercial operations or convenience or fast food operations. Nonetheless, those types of operations have a keen concern for the quality of the deep fried products from day to day and from one facility to the next. In some instances, fast food services use a solid lard type product which is purchased in block form and melted in the fryer prior to use.

Thus, for example, as pointed out previously, not only is the quality of the cooking medium a concern, but the quality of the cooked product and its quality and shelf life are a matter of concern. Accordingly, the nature of the operation and the nature of the product being cooked are of concern to the enterprise preparing the product. For fast food or convenience operations, the immediate quality of the cooking medium is of concern with respect to products to be consumed in the short term. On the other hand, the commercial operations involved in the preparation of potato chips or corn chips, for example, are concerned with the quality of the cooking medium from the standpoint of the shelf life and the quality of the cooked product in the hands of the consumer after a far longer time than that

involved with fast food outlets, for example.

It is also recognized that the costs of the cooking medium are a factor in any commercial, or semi-commercial operation, e.g. school lunch programs, in which a significant portion of the products prepared are deep fat fried. As discussed, hydrogenated vegetable oils and some of the rarer cooking oils are quite stable to oxidation, but may be subject to flavor reversion. The tendency, however, seems to be to use the least expensive product and to use that product for as long as it can be used, consistent with the quality criteria adopted by the user.

Thus, for example, it is recognized by those in the field that rancidity takes place when light, metals or other catalysts cause unsaturated oil molecules to convert to free fatty acid radicals which may, in turn, form hydroperoxides and other organic compounds such as ketones and aldehydes and acids which may have or which in time may develop obnoxious odors or flavors. In the case of oils containing substantial amounts of linoleic acids, for example, soybean oil or rapeseed oil, the oxidation is generally referred to as "flavor reversion" and generally requires a lower degree of oxidation than may be required for oxidative rancidity. Those oils, however, may be less expensive and may be the oils of choice or may be blended with higher priced oils in order to increase the useful life of the cooking medium which may be a combination of inexpensive oils or fats and expensive oils, solely for the purpose of providing a cooking medium having some reasonable useful life. The stability of a cooking medium is usually expressed in terms of AOM, or active oxygen measurement, the latter an indication of the rancidity point of the cooking medium. It is generally recognized that when the peroxide content of the cooking medium reaches 70 meq/kg of oil, the rancidity point has been reached. It is also recognized that once the rancidity point has been reached, the addition of antioxidant material is not effective to reverse the

process. It thus becomes significant to inhibit the formation of the products contributing to rancidity of the cooking medium and the resulting products by controlling or inhibiting the formation of those reaction products which lead to rancidity.

In accordance with this invention, the food-grade and accepted antioxidant materials are used in an effective and permissible amount and in an automatically controlled application to provide the optimum control as permitted by the prevailing safety regulations. The antioxidant material may be any of the natural products mentioned or those known in the art or any of the materials previously mentioned, and which are acceptable for use, alone or in combination. Thus, TBHQ or BHA or BHT or propyl gallate may be used, alone or in combination as permitted by the FDA Regulations, and in combination with other materials.

For example, citric acid may be present in an amount of from 4% to about 20% based on the weight of the active components, while THBQ, or BHT or BHA or combinations thereof (and permissible combinations with propyl gallate) may be present in an amount of from 80% to 100% by weight of the active ingredients. Other components may be present in an amount of between 20% to 70% by weight of the total composition within the capsule, as will be described. The other components may, for example, be carrier materials such as a vegetable oil or a combination of vegetable oils or fats, or glyceryl mono-oleate or propylene glycol, or combinations of all of these carrier materials. The carrier materials are preferably edible products which are soluble in the oil or fat used for frying and preferably are materials which will at least partially wet the antioxidant material for ease of dispersion of the latter in the cooking medium.

In accordance with this invention, the antioxidant material, preferably with a suitable oil type carrier, may be packaged in single dose capsules. The capsule material

is preferably a material approved for use in food products or in the alternative a material which is generally recognized as safe in food products. Also useable are materials which are converted to a char without the release of any objectionable by-products. In other words, even if the capsule material is not fully dissolved in the oil, the capsule material is preferably one which is not converted by the high heat of the oil to a product not approved for human consumption. Thus, for example, any material which is reduced to a carbon char without the formation of objectionable by-products is usable as a capsule material.

In one form, the capsule material may be a gelatin capsule of U.S..P. grade gelatin, available in a variety of forms and shapes and compositions, all of which is well known in that art.. Essentially any packaging material used to package pills or capsules for human use may be used to package the antioxidant material, provided the packaging material is compatible with the antioxidant or other components of the antioxidant filler composition. A particularly useful material is a soft elastic gelatin capsule, sometimes referred to as tropical formulation of gelatin since it is more resistant to heat (for storage and transportation) than the softer grades of gelatin. Depending upon the formulation of the antioxidant material, the shell may be a hard gelatin capsule initially formed of tow parts and assembled together after filling, although this is a less preferred form of the invention since there are practical advantages in having an oil carrier in the capsule. Where an oil carrier is present, it is difficult to achieve a tight seal in order to contain the oil. It is also preferred that the finished capsule be a unitary structure for ease of rupture by the action of the heated cooking medium, as will be described. The shell of the capsule may be of any of the known and approved gelatin formulations, including food grade materials such as gelatin, water, plasticizer, glycerol and optionally

sorbitol. If desired, the capsules may be color coded using FDA approved dyes or other FDA approved techniques, in order to provide color coding as an indication of strength and other variables in the formulation as will be discussed.

In a preferred form, the soft elastic gelatin capsule material is in the form of a ribbon, containing water, and the capsule is filled and formed by conventional rotary die techniques, the latter well known in the art. After formation of the filled capsule, it is dried to remove the water in the gelatin, thus forming a soft pliable gelatin capsule containing an antioxidant composition. In this form, the gelatin capsule may be oleophobic, i.e. oil resistant, where the antioxidant material includes an oil type carrier, but the capsule readily dissolves in water, as is the case with most gelatin capsules.

When formulated in the preferred manner as described, the filled capsule preferably has a density greater than that of the heated and fluid cooking medium with the result that it sinks to the bottom of the cooking medium. The heat of the cooking medium operates to soften the wall of the capsule and to heat up the interior contents of the capsule, generating a moderate internal pressure. It is the simultaneous softening of the capsule and the increase of the internal pressure which causes the capsule to rupture slowly thereby permitting intermixing of the cooking medium with the capsule contents.

As a result of the intermixing, the capsule contents are dissolved in the cooking medium, which is generally circulated either through a pumping system or because of the natural movement of the heat, or manually stirred and the dissolved contents of the capsule is essentially uniformly dispersed throughout the cooking medium in a relatively short time. It is for this reason, a preferred form of the invention, that the capsule is sufficiently air tight and sufficiently filled to permit the build up of internal pressure in order to effect rupture of the outer capsule

wall in the cooking medium. Thus, to facilitate this type of rupture, it is preferred that the wall of the capsule be relatively thin, for example in the range of from 0.010 to 0.020 of an inch, and preferably of a composition that softens at the temperature of the heated cooking medium. By way of example, the cooking medium may be heated to between 140 to 160 degrees F., or higher (60 to 71 degrees C. or higher) to bring about a flowable and moving cooking medium. Generally, the antioxidant material is dissolved in about 20 minutes.

To assure reasonably prompt dissolution of the antioxidant material, it is preferred that the normally powder type materials which form the effective antioxidant be predispersed in a carrier which is compatible with the cooking medium, for example, an appropriate edible oil or fat or combination thereof which does not adversely impact the character of the cooking medium. Such a procedure, in effect, pre-wets the powder with oil and facilitates dispersion and dissolution in the cooking medium. If a pure dry powder is used, there is the practical problem of dissolving such a material in a relatively large bath of oil-like fluid, and one runs the risk of incomplete dissolution of the effective ingredients. Since the principal, although not only application of the present invention, is in the fast food types of operations, there are practical reasons for taking appropriate steps to assure that the antioxidant materials are properly and easily used, having in mind that the users thereof at the site of use may not be highly trained.

After the capsule ruptures, it remains at the bottom of the cooking medium bath and is usually carmelized, in the case of gelatin, or may be cooked to a char. In either event the residue of the capsule is not a troublesome contaminant since it may be removed by the filtering system or during the normal oil cleaning operations. Its presence in the cooking medium and even its presence with the food

product being cooked does not present a contamination problem any more severe than that of a charred piece of potato or the like. Even if the char residue ends up in the food product, it may be consumed or discarded by the consumer. It is for this reason that FDA approved gelatin products or those used in the packaging of pills and the like are preferred. In the event that the gelatin is color coded, there is no dispersion of the color into the cooking medium and this is another reason for the preferred use of gelatin materials.

In the single dose, prepacked antioxidant of this invention, virtually any of the FDA approved antioxidant materials or approved combination of materials may be used as the active ingredients. Many have already been discussed and many are referred to in the patent literature cited. For purposes of explanation, reference will be made to TBHQ, BHA, BHT and propyl gallate, although the present invention is not limited to those materials. The single dose prepacked product of this invention is formulated with a known and effective amount of approved antioxidants, having in mind the maximum permitted amounts as set forth by the FDA. Since the bulk of deep fat frying operations are in different size frying units, one of the advantages of this invention is that the amount of antioxidant material may easily be packaged to accommodate a particular size fryer or a range of sizes of fryer.

The size of fryer usually is incremental, as follows:

35 pounds.......... 15.876 kg
50 pounds.......... 22.68 kg
70 pounds.......... 34.02 kg
100 pounds.......... 45.36 kg

although other sizes may be used. The oils typically used are vegetable oils, such as soya oil, cottonseed oil or corn oil, and tallow. The more common combinations are 90% tallow and 10% vegetable oil, or pure vegetable oil. In some cases 100% peanut oil is used. It is not unusual for

50% of the oil to be used up in a commercial fast food operation as the result of carry out with the product or evaporation or both. In such a case, new oil is usually added on a daily basis, makeup oil so-called. The makeup oil may contain an antioxidant to prevent oxidation in shipping and storage, prior to use. Usually the percentage of antioxidant in new (unused) or makeup oil is about 0.0055% by weight of the oil, although in some instances it may be the maximum permitted by FDA regulations, i.e., 0.02% by weigh based on the weight of the oil..

It is known that the antioxidant present in cooking oil is rapidly used up under the conditions of continuous use, as is the case for most commercial operations. Where the cooking oil temperature is about 350 degrees F. (176 degrees C.), there is a rapid depletion of the antioxidant in the first eight to nine hours of cooking . At higher temperatures, e.g 190 to 200 degrees C. (375 to 395 degrees F.), the half life of the antioxidant is about four and one-half hours. It is also generally recognized that an effective amount of antioxidant material such as BHT, BHA and TBHQ, for example, during cooking operations is in the range, nominally, of about 0.01% by weight based on the weight of the oil. It is to be understood however that the effective amount is in the range of between about 0.0055% and the maximum amount permitted under the current FDA regulations, i.e., 0.02% by weight. For purposes of simplicity, the figure 0.01% is used, it being understood that the effective amount is in the range indicated. Thus, by way of illustration and in terms of the fryer size previously mentioned, the approximate effective amount and the maximum amount of antioxidant are as follows:

weight in lbs.	weight in kg.	effective amount in grms. 0.01%	maximum amount in grms. 0.02%	amt. in gals.
35	15.876	1.587	3.175	3.395
50	22.68	2.268	4.536	4.85
75	34.02	3.402	6.804	7.27
100	45.36	4.536	9.072	9.7

On the basis of these data, it becomes apparent that even if makeup oil is added, the cooking medium contains far less than an effective amount for cooking, even though it may be effective for storage and shipping. Calculation will demonstrate that even the addition of makeup oil containing between 0.0055% and 0.02% by weight of antioxidant will never provide an amount of antioxidant which is within the nominal range of effectiveness for cooking in those cases where cooking is carried out in the usual commercial mode. It is for this reason that the separate addition of antioxidant is desired, but under conditions that will not exceed the maximum permissible levels.

It is preferred in accordance with this invention to provide a series of different sized capsules, each formulated to provide an appropriate effective amount of antioxidant, but which, if added (assuming no loss and ignoring the half-life) provides less than the maximum permissible amount. The following table shows the amount of antioxidant which may be present (0.0055%) in the new or makeup oil and the amount needed for the higher end of the range for effectiveness and the amount needed to reach the maximum limits.

size in lbs.	size in kg.	amount in grms. present	amount in grms. effective to add	amount in grms. maximum to add
35	15.876	0.87318	0.62682	2.30202
50	22.68	1.2474	1.0206	3.2886
75	34.02	1.871	1.531	4.933
100	45.36	2.495	2.041	6.577

From the above data, it becomes clear that is possible to add antioxidant over and above that initially present in the oil material such that the total percentage by weight of the antioxidant is below the maximum permissible limit, but is present in an effective amount.

In some instances, the new cooking medium contains 0.02% by weight of antioxidant and the amount of antioxidant which may be added may be calculated from the half-life characteristic of the oil as a result of use. In this tabulation it is assumed that the user follows a procedure followed by some of the fast food commercial users. i.e., the oil is initially supplied as a block of lard in the amount of 50 pounds and containing 0.02% by weight of antioxidant. The block is placed in a fryer and melted and then heated at cooking temperatures for a one day cycle. At the start of the second day, the new oil is used in the preparation of food products.

Assuming a half-life of nine hours and a cooking cycle of eighteen hours, i.e., 6 AM start and 12 midnight ending cycle per day, (two half-lives) and assuming the conditions given, the data are as follows:

size in kg. (lbs)	amt. in grms. initial	amt. in grms. half-life	max. amt.	eff. amt.	amt. to add max.
15.876 (35 lbs)	3.175	0.794	3.175	1.587	2.381
22.68 (50 lbs)	4.536	1.134	4.536	2.268	3.402
34.02 (75 lbs)	6.804	1.701	6.804	3.402	5.103
45.36 (100 pounds)	9.072	2.268	9.0782	4.536	6.804

From the above data, it seems apparent that if the usual procedure is followed of heating at cooking temperature for a one day cycle, then the amount of antioxidant present before the preparation of food starts is well below the maximum effective level at the start of food preparation. At the end of the third day of heating, the amount of antioxidant is substantially reduced. The result is that the oil tends to undergo rancidity and does not last for any appreciable length of time. Extending these data out for seven days, even assuming the addition of 20% by weight of make-up oil daily, the oil never achieves an effective amount of antioxidant due to the half-life characteristic of the antioxidant. The result is oil that becomes rancid and should be replaced.

By the present invention, the daily addition of a single or multiple dose capsule to a given amount of cooking oil after one cooking cycle of at least one half-life results in a significant extension of the useful life of the oil before it becomes rancid. By the practice of this invention, the useful life of the oil may be doubled and even tripled, depending upon the nature of the oil and the amount of carry out of the oil with the cooked product. the result is a reduction in the cost of oil used, better and more uniform quality of product, all with ease of use and a relatively simple methodology which tends to maintain an

effective amount of antioxidant in the cooking medium but one which is well below the maximum level permitted under the current FDA regulations.

The following data, calculated on the basis of a starting concentration of 0.02% by weight of antioxidant and a pre-cooking cycle of one and two half-lives (nine hours per half-life), demonstrates the advantages of the present invention. These data assume a fryer containing 50 pounds (22.68 kg) of oil with the additions indicated after the first start day.

	amount at start	added amt. in grms.	amount after add.	half-life 1st 2nd	amount at end 1st 2nd	effect. amt. max. amt.
1.	4.85	- - -	4.85	2.425	2.425	2.425
	4.85	- - -	4.85	1.213	1.213	4.85
2.	2.425	1.85	4.275	2.138	2.138	2.425
	1.213	1.85	3.063	0.766	0.766	4.85
3.	2.138	1.85	3.988	1.994	1.994	2.425
	0.766	1.85	2.616	0.654	0.654	4.85
4.	1.994	1.85	3.844	1.922	1.922	2.425
	0.654	1.85	2.504	0.626	0.626	4.85
5.	1.922	1.85	3.772	1.886	1.886	2.425
	0.626	1.85	2.476	0.691	0.619	4.85
6.	1.886	1.85	3.736	1.868	1.868	2.425
	0.619	1.85	2.469	0.617	0.617	4.85
7.	1.868	1.85	3.718	1.859	1.859	2.425
	0.617	1.85	2.467	0.616	0.616	4.85
8.	1.859	1.85	3.709	1.855	1.855	2.425
	0.616	1.85	2.466	0.616	0.616	4.85
9.	1.855	1.85	3.705	1.853	1.853	2.425
	0.616	1.85	2.466	0.616	0.616	4.85
10.	1.853	1.85	3.703	1.851	1.851	2.425

These data are interesting because they demonstrate a steady state condition is achieved at about the seventh to the tenth day. These data also show the effects of cooking for

an extended period of time without the addition of antioxidant. The amount of antioxidant of 0.616 grams for 22.68 kg. of oil represents about 0.0027% antioxidant, well below the 0.0055% by weight believed to be the lower limit for effectiveness.

Thus, in accordance with the present invention, a series of capsules each containing a specified amount of antioxidant may be formulated to provide an amount of antioxidant which is within the effective range previously noted. For example, a capsule formulated for 35 pounds of oil may be used in multiples for oil which is a multiple of 35 pound, e.g., two 35 pound capsules for 70 pounds of oil or two 50 pound capsules for 100 pounds of oil.

By way of example, capsules may be formulated as follows:

Example I

TBHQ	860 mg		69.9% of antioxidant
BHA	370 mg		30.1% of antioxidant
Sub total	1230 mg		39.1% of capsule contents
Oil	1920 mg		60.9% of capsule contents
Total fill	3150 mg		
Capsule	Gelatin	606 mg	
	Glycerin	338 mg	
Total capsule weight		944 mg	
Total weight		4094 mg	

This capsule may be used for 35 pounds of oil or multiples thereof.

Example II

TBHQ	1300 mg	70.3% of antioxidant
BHA	550 mg	29.7% of antioxidant
Sub total	1850 mg	58.7% of capsule contents
Oil	1300 mg	41.3% of capsule contents
Total fill	3150 mg	
Capsule	Gelatin	606 mg
	Glycerin	338 mg
Total capsule weight		944 mg
Total weight		4094 mg

This capsule may be used for 50 pounds of oil or multiples thereof.

Example III

TBHQ	1720 mg	69.9%,of antioxidant
BHA	740 mg	30.1% of antioxidant
Sub total	2460 mg	64% of capsule contents
Oil	1380 mg	36% of capsule contents
Capsule	Gelatin	606 mg
	Glycerin	338 mg
Total capsule weight		944 mg
Total weight		4748 mg

This capsule may be used for 75 pounds of oil or multiples thereof.

The above Examples are merely representative of various possible formulations which may be used in the practice of this invention. Other antioxidants or permissible combinations of antioxidants may be used, and other materials may be included, for example, citric acid. In the above Examples, the oil used was soybean oil, although it is understood that other edible oils or fats or combinations may be used. In the formulations above noted, the resultant fill material had the consistency of a viscous liquid, and the antioxidant was dispersed in the oil, although a small amount was dissolved in the oil. In part, the above formulations were used since the rheology of the material was compatible with the capsule formation and processing

equipment. The amount of antioxidant material present in the capsule may be in the range of 25% to 80% based on total weight of the capsule, while the oil may be present in the range of from 30% to about 65% of the capsule weight. Variation in the strength of the capsule is achieved by increasing the weight of the antioxidant and reducing the amount of the oil, if one is present.

It becomes apparent from the above data that each of the formulations has been compounded to add an amount of antioxidant which is initially above the effective amount but less than the maximum permissible amount. To assure that the proper amount is added to the proper quantity of oil, it is preferred that each of the capsules be color coded, as by coloring the capsule itself or by coloring the package in which the individual capsules are hermetically sealed. Also, the packing may be such that a known number of capsules is packed in a carton, for example, 28 or 30 capsules per carton. The carton is preferably provided with a log indicating the date and the time and the number of capsules used and the person making the addition. In this way, reasonable steps can be taken to assure that the proper dosage and recommended dosage is used. In the event that the count of remaining capsules and the log do not agree, i.e., there are less capsules remaining in the carton than show up on the log, the oil should be discarded and new oil used.

One of the practical aspects of the present invention is that not all oil from various sources is formulated with the same amount of antioxidant to start with. It is not permitted to use more than 0.02% of the antioxidants mentioned under the current FDA regulations. Thus, it is assumed that the oil suppliers adhere to the mandates of the FDA. The formulations here described have been suggested on the assumption that the starting oil contains no more than the permitted amount or type of antioxidant. It is also apparent that capsules of much larger size than those here

described may be used for the very large commercial operations with the advantage of control of the addition of an effective amount of antioxidant without the necessity of expensive pumps and plumbing.

For example, it is possible to disperse the antioxidant in an edible oil and measure out an appropriate amount in fluid measurement. The difficulty with this procedure is that the antioxidant is not totally soluble in the relatively small amount of oil used as the dispersant, i.e., the material is a dispersion of a solid in an oil with only a portion of the solid being soluble. If care is not taken to assure uniform mixing of the antioxidant in the oil prior to measurement, it is possible to use an antioxidant rich fraction of the mixture with the result that more antioxidant is added than is permissible.

The antioxidants usually used, and those mentioned herein, generally have a tendency to rise to the surface of the oil with which they are compounded. The result may be, if care is not exercised, to add non-uniform and uncontrolled amounts of the effective material by the addition of an antioxidant rich portion of the oil. Further, since the antioxidant material tends to rise to the surface of the oil, there is the danger that if the antioxidant is not completely dispersed, undissolved material may be deposited on the food product in an amount which may be excessive. By this invention, these difficulties are largely eliminated through the use of single or multiple dose capsules having a known amount of active material in each capsule and wherein the capsule sinks to the bottom of the oil bath where it may readilly dissolve.

In accordance with this invention the preferred procedure is to use one capsule per day per unit quantity of oil. For multiple quantities of oil, appropriate adjustment is made. For capsules intended for use in 35, 50 and 75 pound fryers (fryers containing 35, 50 or 75 pounds of oil),

the same may be used for multiples of 35 50 and 75 pound lots, e.g. 2 capsules intended for use in 35 pounds may be used daily for a 70 pound fryer, and so forth. Normally, no addition is made to the oil until it has been heated for one normal cycle, i.e., has been heated or heated and used for cooking for at least 4.5 to 9 hours or more. The capsule or capsules are added to the oil while the latter is heated and after addition the oil may be stirred gently or may be in movement due to the heating and convection currents. Where a fryer is equipped with a circulation and cleaning system as most commercial fryers are, the natural flow of the circulation system is sufficient.

While the material and method of the present invention are an advance in retarding the rancidity of edible oils, it must be understood that antioxidants do not prevent oxidation; at best they can only slow it up and thus extend the useful life of the oil.

It will be apparent to those skilled in the art from the above description of the details of this invention that various modifications and alterations may be made based on the detailed disclosure herein. These modifications should not be deemed beyond the scope of this invention as set forth in the appended claims.

What is claimed is:

1. A method of extending the useful cooking life of an edible oil or fat or combinations thereof optionally containing an antioxidant which comprises the steps of:

adding to a predetermined quality of heated and fluid edible oil or fat or combinations thereof at least one capsule containing antioxidant material which is soluble in said oil or fat or combinations thereof, said antioxidant material being dispersed in a fluid carrier which is an edible oil or fat or combinations thereof and which is soluble in said fluid edible oil or fat combinations thereof,

said capsule including an outer sealed shell of an edible material which is insoluble in said edible oil or fat or combinations thereof and which upon thermal degradation results in a consumable by-product,

said capsule shell and contents having a density greater than the density of the heated fluid and containing a predetermined amount of antioxidant material related to the predetermined amount of said edible oil or fat or combinations thereof,

said antioxidant material being present in said capsule in an amount sufficient to inhibit the oxidative rancidity of said oil or fat or combinations thereof by maintaining the amount of peroxides in said oil or fat or combinations thereof at a level below about 70 meq/kg of said oil or fat or combinations thereof for a predetermined period of time,

maintaining said capsule in contact with said heated fluid medium to effect heating thereof and rupture of said capsule and release of said contained antioxidant material into said fluid for dissolution of the antioxidant material therein, and

thereafter adding to said heated fluid at least one or more additional capsules at predetermined intervals to make up for at least part of the loss of antioxidant material introduced by the previous addition and optionally present

thereby to inhibit the oxidative rancidity of said edible oil or fat or combinations thereof.

2. A method as set forth in Claim 1 wherein the amount of heated fluid is 35 pounds, 50 pounds, 75 pounds, or 100 pounds, or multiples thereof.

3. A method as set forth in Claim 1 wherein the amount of antioxidant material in said capsule is sufficient to provide an antioxidant concentration of between 0.0055% and 0.02% by weight of said edible oil or fat or combinations thereof after the addition of said capsule and for a predetermined period of time.

4. A method as set forth in Claim 1 wherein said capsule is a gelatin capsule.

5. A method as set forth in Claim 1 wherein said antioxidant material is selected from the group consisting of BHA, BHT, TBHQ and mixtures thereof.

6. A method as set forth in Claim 5 wherein said capsule is a gelatin capsule and wherein the amount of antioxidant material in said capsule is sufficient to provide an antioxidant concentration of between 0.0055% and 0.02% by weight of said edible oil or fat or combinations thereof after addition of said capsule and for a predetermined period of time.

7. A method as set forth in Claim 1 wherein said capsule is a soft gelatin capsule which is heated by said heated fluid to effect softening of said capsule and a pressure build-up within said capsule thereby rupturing said capsule to release the contained antioxidant material.

8. A method as set forth in Claim 1 wherein at least one capsule is added each day during the use of said edible oil or fat or combinations thereof as a cooking medium for at least eight hours per day.

9. A capsule for providing a single predetermined amount of antioxidant for addition to a cooking medium to inhibit oxidative rancidity thereof comprising:

an outer sealed shell of an edible material which upon

thermal degradation results in an edible by-product,

said outer sealed shell containing a predetermined amount of an antioxidant material dispersed in a carrier which is a fluid and which edible and which is soluble in said cooking medium,

said antioxidant material being present in an amount by weight of between 30% and 65% of the capsule weight, and

said shell having a wall thickness of less than about 0.020 of an inch.

10. A capsule as set forth in Claim 9 wherein said shell is composed of a one piece shell of a gelatin material.

11. A capsule as set forth in Claim 9 wherein said antioxidant material is selected from the group consisting of BHA, BHT, TBHQ and mixtures thereof.

12. A capsule as set forth in Claim 9 wherein said shell of said capsule is formed of an oleophobic material and wherein said shell is a one piece completely sealed capsule.

13. A capsule as set forth in Claim 9 wherein said shell is color coded for identification.

14. A capsule as set forth in Claim 9 wherein said antioxidant material is present in an amount of between 25% and 80% of the capsule weight.

15. A capsule as set forth in Claim 9 wherein the amount of TBHQ is at least twice that of the remaining antioxidant.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US88/02179

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [8]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(4): A23L 1/01
U.S.CL.: 426/541

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
U.S.	426/98, 99, 138, 417, 438, 541, 576, 601, 604, 654

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	US, A, 3,789,015 (MATSUKAWA) 29 JANUARY 1974.	9-15
A	US, A, 3,317,433 (EICHEL) 02 MAY 1967	9-15
Y	US, A, 3,867,556 (DARRAGH) 18 FEBRUARY 1975 SEE THE ENTIRE DOCUMENT	9-15
Y	US, A, 4,695,466 (MORISHITA) 22 SEPTEMBER 1987. SEE THE ENTIRE DOCUMENT	9-15
A	US, A, 3,851,083 (BROOKING) 26 NOVEMBER 1974.	1-8
A	US, A, 4,710,391 (KIRN) 01 DECEMBER 1987	1-8
A	THE USE OF ANTIOXIDANTS IN DEEP FAT FRYING (SAIR) 1951 FOOD TECHNOLOGY FEBRUARY ISSUE PAGES 69-73	

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
06 December 1988	15 FEB 1989
International Searching Authority	**Signature of Authorized Officer**
ISA/US	Carolyn Paden Carolyn Paden

Form PCT/ISA/210 (second sheet) (Rev.11-87)